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VORTICAL CLOUD SYSTEMS OVER THE TROPICAL ATLANTIC DURING THE 1967 HURRICANE SEASON

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ABSTRACT

Stronger tropical depressions are associated with a recognizable vortical cloud pattern. This note summarizes the number and history of vortical cloud systems observed over the tropical Atlantic during the 1967 hurricane season. The appearance of a "vortical cloud" does not necessarily imply the depression will intensify.

Tropical meteorologists have known since the midforties that the rainbands observed by radar during the early stages of tropical storm development have a characteristic "spiral-band" curvature (e.g., Maynard, 1945, and Wexler, 1947). Similarly curved cumulus cloud bands, the cloud counterparts of radar-observed rainbands, are often clearly shown in satellite pictures of tropical cyclones. Such spiral-band clouds have been recorded frequently by satellites since 1960, and have been used in interpretive studies by a number of investigators in recent years (e.g., Fett, 1968, Fritz et al., 1966, Johnson, 1963, Merritt, 1964, and Sadler, 1964).

These satellite-observed spiral-band cloud patterns usually suggest the presence of a low-level circulation or closed Low. Thus each such system was earlier generally called a "vortex" or "vortex pattern." More recently the term "vortical pattern" has come into common use. The vortical cloud system typically associated with tropical depressions and storms is a particular type of vortical pattern. It has several distinctive characteristics and may be easily distinguished in most cases from other types of vortical patterns (such as those of extratropical wave cyclones and weakening cyclones, and extratropical "vorticity center" conditions).

Two primary characteristics distinguish the more marked vortical cloud patterns observed during the early stages of tropical storm development. The first is a well-defined set of low-level curved cumulus bands that spiral inward approximately parallel with the low-level winds. These sets of curved bands vary somewhat in appearance and organization but vary over a small range. Well-organized arrays of such roughly concentric curved cumulus bands are among the most striking conditions to be seen in satellite pictures.

The other characteristic is an extensive middle and high cloud overcast which is usually conspicuously present east and northeast of the center of the vortical system and which often has a roughly "comma" shape, the "comma configuration" of Fett (1968). Outflow at the cirrus level is often indicated by the structure of the overcast in high quality weather satellite pictures. The two primary characteristics are shown schematically in figure 1.

Well-defined tropical vortical patterns generally imply the presence of a surface closed circulation. Sadler (1964) reports that this type of pattern develops before tropical storm intensity is reached. Fett (1968) observed that

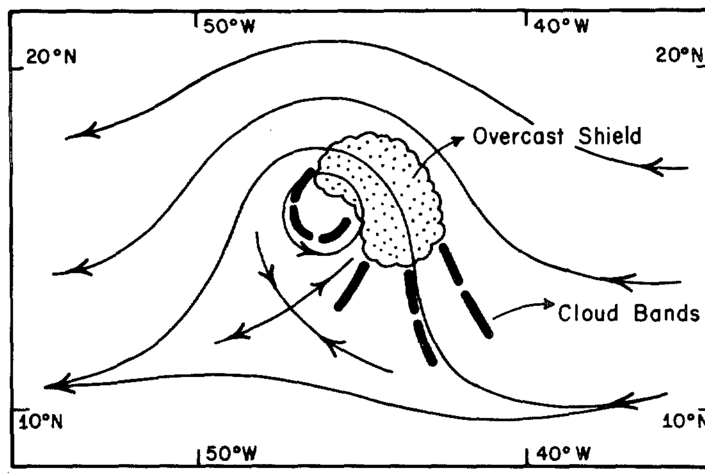

FIGURE 1.—Schematic of a tropical vortex cloud pattern.

maximum surface winds of 20 to 30 kt were typical of his "stage C" disturbances, and Merritt (1964) suggested that the maximum winds of comparable disturbances were usually less than 25 kt.

Merritt (1964) states that "vortex cloud distributions" are indicative of tropical depressions, and that "this type can be expected to intensify into a hurricane."

Two such vortical clouds observed in 1964 near the African coast are shown in figure 2. Because of the gaps in coverage of the TIROS satellites of that year, these systems could not be tracked with confidence and may not have been seen again. They did not appear on the surface charts, doubtless in part because of sparsity of data. Examples of this kind have cast doubt on the validity of Merritt's statement and pose a significant operational question: After a vortical cloud pattern appears, what statistically are the chances for future deepening?

The primary purpose of this note is to summarize the frequency of occurrence and history of the vortical cloud systems that were observed over the eastern and central tropical Atlantic Ocean during the 1967 hurricane season.

The recently available digitized mosaics of satellite-observed cloud conditions prepared by the National Environmental Satellite Center provide an excellent and exciting new tool for investigations of this type. The advantages of having daily rectified pictures of a standard map projection are noteworthy and represent an important technological advance.

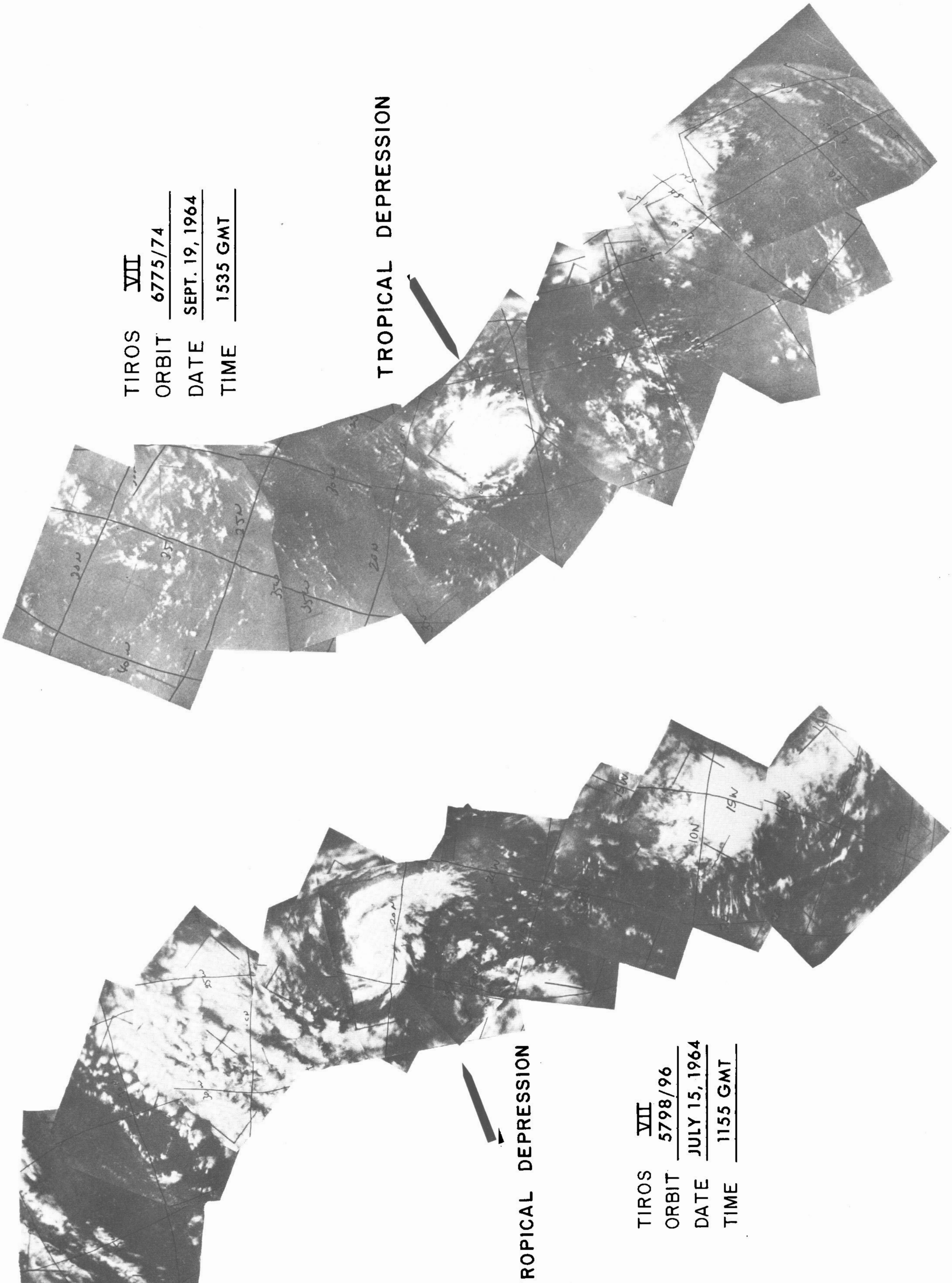

FIGURE 2.—Two vortical clouds in 1964 that did not develop into tropical storms.

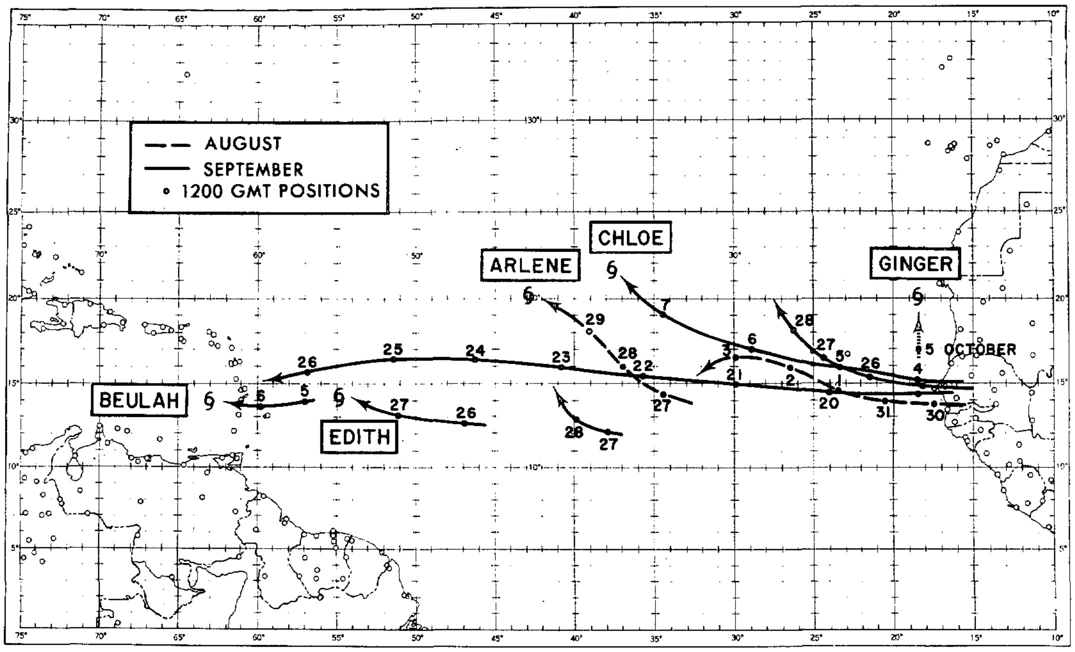

FIGURE 3.—Tropical vortex cloud tracks for the hurricane season of 1967.

Simpson et al. (1968) summarize the Atlantic tropical disturbances of 1967 and present tracks for the depressions observed during the period June through October. The portions of these depression tracks along which distinct vortical clouds were observed by satellite are shown in figure 3. The depressions that developed into storms are indicated by name. The tracks of Lows that weakened are terminated where the vortical pattern was lost. Of the 29 depressions whose tracks are given in Simpson et al. (1968), 18 originated over the Atlantic east of the Lesser Antilles or over Africa. Half (nine) of these reached the intensity of "stronger depressions," as indicated primarily by a particularly well-marked vortical pattern. Of these nine stronger depressions, nearly half (five) deepened further and became tropical storms. The greatest frequency of occurrence of stronger depressions was in August and September.

Depression intensity estimates for the 31 positions shown in figure 3 are listed, by date, in table 1. Although some of these estimates may be questioned because of data sparsity, most are believed to be reasonably good. The maximum winds are, in general, in the range 20–30 kt, in agreement with the results of the earlier studies cited above. An exception is provided by the winds in the region of the Cape Verde Islands and eastward to the African coast, where reported winds were generally less than 20 kt. Possibly this may indicate that time is required for the surface circulation to become well organized over the ocean as the systems move westward away from the strong low-level monsoonal conditions of West Africa.

Table 1 also includes a five-category subjective estimate of the change of each vortical cloud system during the next 24-hr period. The estimates were based, to a large extent, upon changes in low-level band structure and changes of the overcast shield. These changes are summarized in table 2. Note that approximately 10 examples fall in each of the three major categories. Of the 10 that became better developed, five reached tropical storm intensity. That is, only five of 31 (or about 15 percent) of the vortical clouds observed deepened to tropical storm intensity in the next 24 hr. A similar fraction dissipated during the following day. The most frequent occurrence was little or no change. Whether these statistics are representative of a longer period mean, or are representative for 1967 only, is not yet known. This will be determined when the comparable statistics for the next few years are obtained.

Two cases of dramatic weakening were observed in 1967. One of these cases is illustrated in figure 4. Beginning in late August, a series of stronger depressions moved westward off the coast of West Africa. Three such depressions are shown in the sequence of daily digitized mosaics of figure 4. The first of these depressions passed Dakar on August 24, and by the 28th had a well-developed vortical cloud pattern. This system became Arlene on August 30. The second depression moved over the Cape Verde Islands on September 1 and became well organized on September 2. It remained well organized on September 3, but weakened rapidly between the 3d and 4th. The third depression crossed the coast on September 3, and deepened to become tropical storm Chloe on September 8. From the standpoint of cloud organization, the second depression appeared to be a very promising tropical cyclone. It was more impressive on September 2 than the depressions just west and east of it that became Arlene and Chloe. Yet it dissipated, and did so at a remarkable rate. The reasons for the weakening of this cyclone and the strengthening of the other two are not readily apparent

Two other depressions near the Cape Verde Islands are shown in figure 5. Although the cloud systems of these disturbances appear similar, subsequent development was quite different. The depression shown just west of Africa on September 27 weakened almost as rapidly as the second depression of figure 4. In contrast, the disturbance

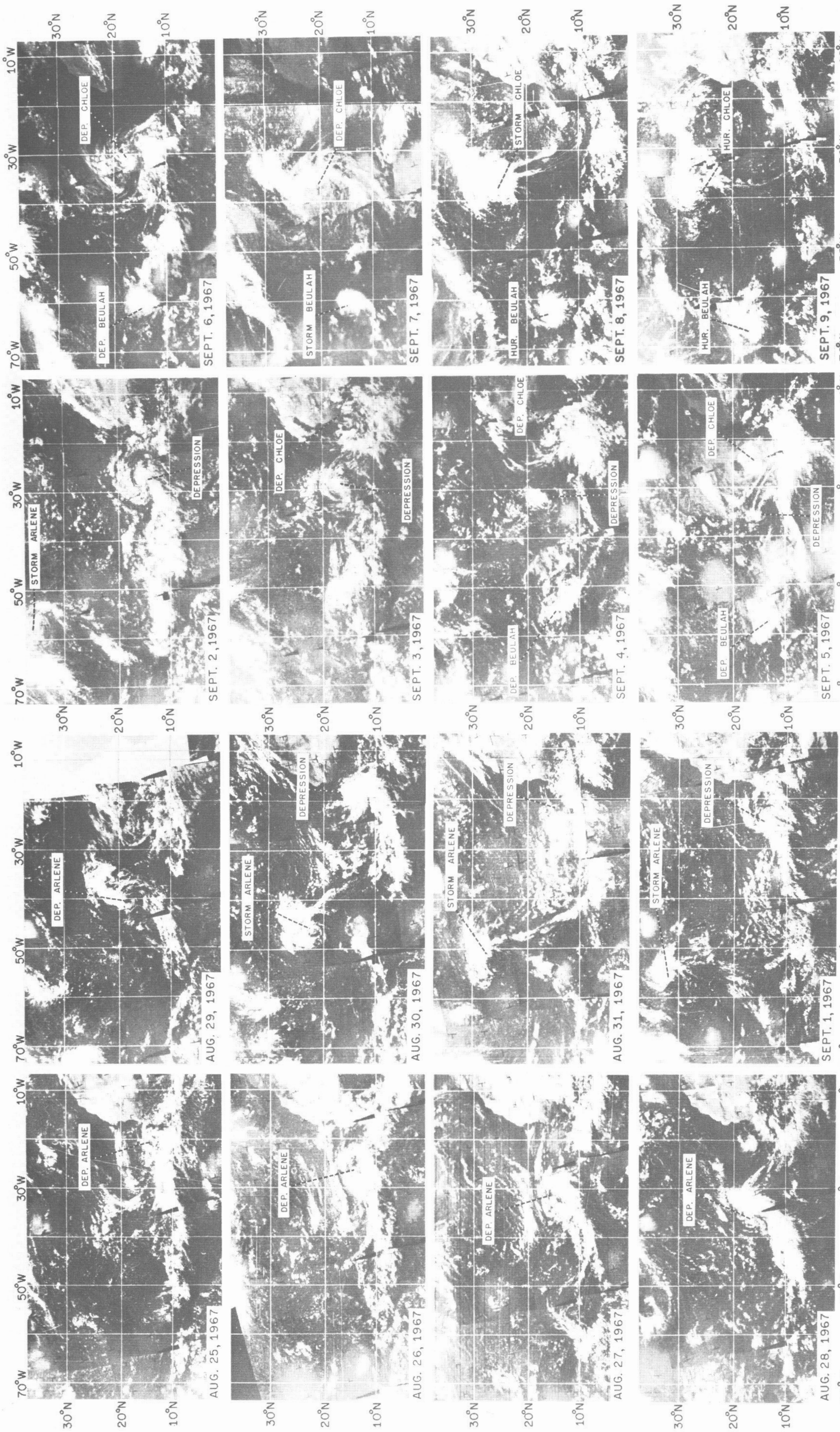

FIGURE 4.—A series of daily digitized cloud mosaics showing the development of Arlene, Beulah, Chloe, and a fourth depression that weakened rapidly on September 4 near 16°N, 33°W.

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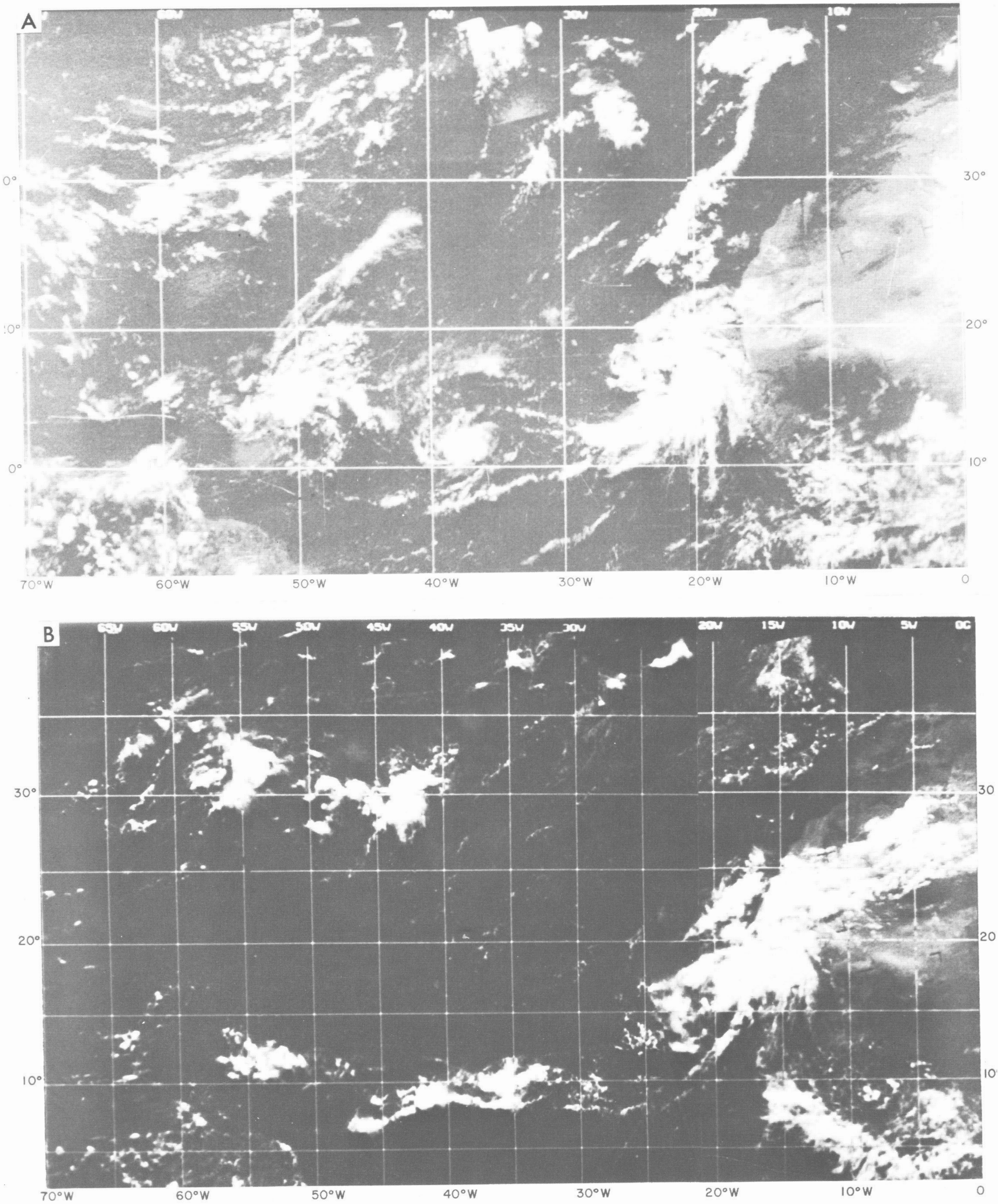

FIGURE 5.—(A) Sept. 27, 1967, and (B) Oct. 5, 1967. The two depressions seen near the African coast had similar cloud structures, but subsequent development was quite different. The September 27 depression weakened rapidly the next day. Ginger formed on October 6. Other depressions on September 27 are seen near 12°N, 38°W, and 13.5°N, 51°W.

TABLE 1.—*Tropical depressions of 1967 that acquired a vortex cloud pattern. The table lists the dates on which a vortical cloud was evident, an estimate of intensity, and a subjective evaluation of the change in cloud character during the subsequent 24-hr period.*

Date	Estimated minimum pressure (mb)	Estimated maximum winds (kt)	24-hr change in cloud character
Aug. 27	1008	20	better developed
28	1008	20	little or no change
29	1008	40	became Arlene
30	Deepened to tropical storm Arlene		
Aug. 30	1012	10-15	little or no change
31	1011	10-15	little or no change
Sept. 1	1010	20	better developed
2	1010	20	little or no change
3	1012	30	dissipated
Sept. 4	1008	15	little or no change
5	1008	25	little or no change
6	1008	25	little or no change
7	1006	30-35	became Chloe
8	Deepened to tropical storm Chloe		
Sept. 5	1010	25	better developed
6	1006	25	became Beulah
7	Deepened to tropical storm Beulah		
Sept. 19	1011	15	little or no change
20	1011	15	less well-developed
21	1012	15	less well-developed
22	1012	25	less well-developed
23	1012	30	little or no change
24	1012	25	little or no change
25	1012	25	little or no change
26	1010	30	dissipated
Sept. 26	1005	25	better developed
27	1005	25	became Edith
28	Deepened to tropical storm Edith		
Sept. 27	1008	25	little or no change
28	1008	25	dissipated
Sept. 25	1010	10-15	better developed
26	1010	20	little or no change
27	1007	25	less well-developed
28	1008	25	dissipated
Oct. 5	1010	25	became Ginger
6	Deepened to tropical storm Ginger		

shown over the same area on October 5 became tropical storm Ginger 1 day later. Also of interest are the two other depressions shown in the September 27 picture. The one near 12°N, 38°W, formed in the mid-Atlantic on the 26th and disappeared on the 29th. The other, near 13.5°N, 51°W, developed into Edith the next day.

SUMMARY

The following conclusions and statistics were obtained for the vortical systems observed over the Atlantic during the summer of 1967. Although the 1967 hurricane season was unusual in several respects (e.g., Sugg and Pelissier, 1968), the 1967 statistics may prove to have a more general validity.

(1) The cloud system associated with a tropical depression develops, typically, a well-defined tropical vortical pattern when the maximum surface winds reach the range 20 to 30 kt. Two primary characteristics distinguish this tropical vortical pattern. They are 1) a well-defined set of low-level cumulus "spiral bands" oriented approximately parallel to the low-level winds, and 2) an overcast shield generally east of the vortical cloud center.

(2) Well-marked tropical vortical cloud patterns provide a useful basis for defining and identifying a class of stronger depressions. This category corresponds well with those of Fett's stage C and C+ disturbances and Merritt's "intense disturbances." About half of the

TABLE 2.—*Summary of changes in the vortical clouds listed in table 1 during the subsequent 24-hr period*

Less well-developed		Little or no change	Better developed	
Lost vortical pattern	Retained vortical pattern		Remained depression	Became tropical storm
4	4	13	5	5
Total 8		13		10

Atlantic depressions observed in 1967 belong to the class of stronger depressions. About half of the stronger depressions became tropical storms. Thus, about 25 percent of the 1967 depressions became named storms.

(3) The appearance of a tropical vortical cloud did not necessarily indicate that a depression was deepening or or would deepen, or that a tropical storm would develop by the next day. In 1967, approximately two-thirds of the depressions either weakened or changed very little in the next 24 hr. Even when deepening occurred, tropical storm intensity was reached in only half of the cases. Vortical clouds preceded intensification to a named tropical storm by 1 day only 15 percent of the time for this sample of 31 occurrences.

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